Fourth Annual Conference on Carbon Capture & Sequestration

Developing Potential Paths Forward Based on the Knowledge, Science and Experience to Date

Capture and Separation – Sorbents 1

Pilot Plant Testing of Aqueous Piperazine and Potassium Carbonate for CO_2 Capture

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Outline

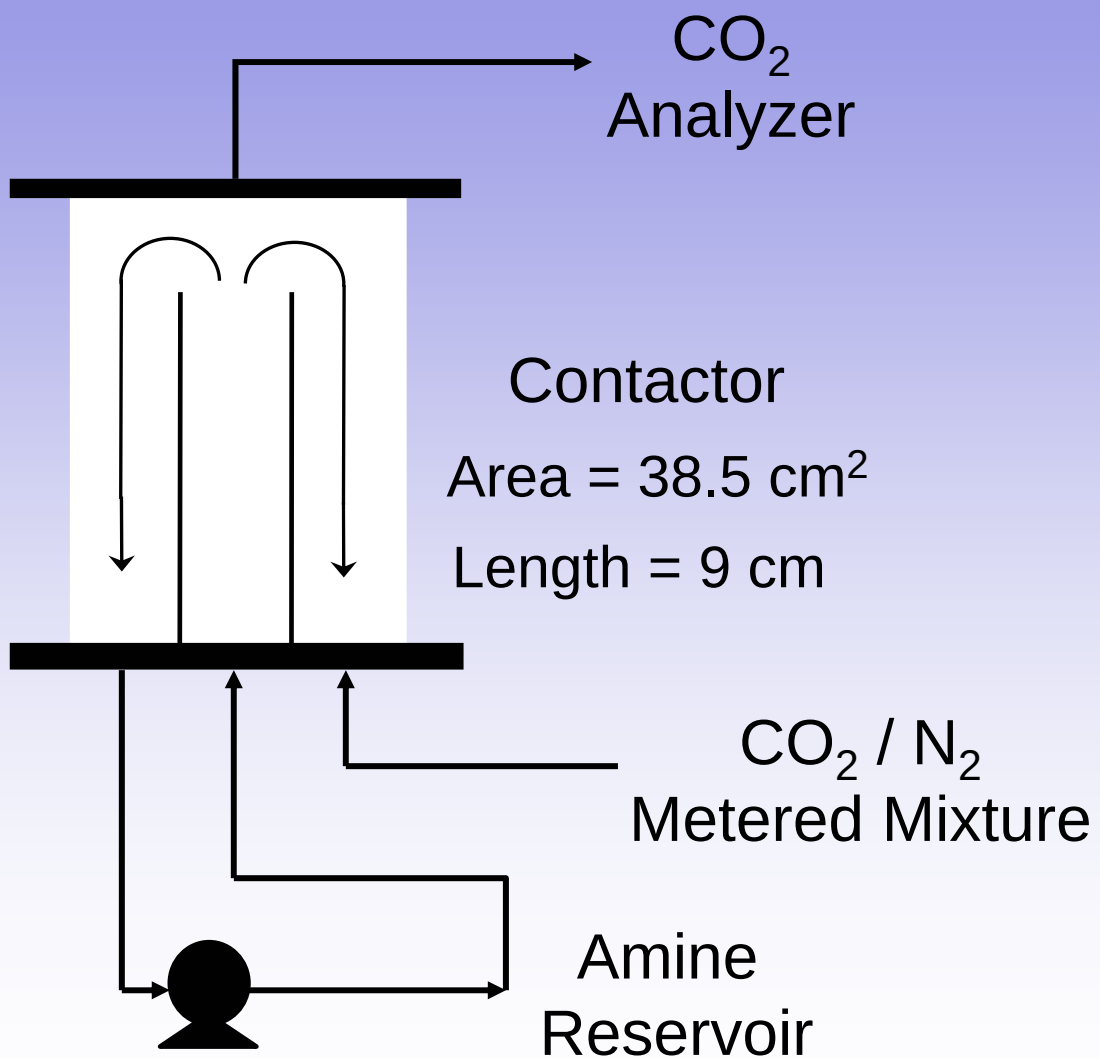
- Advantages of K_2CO_3/Piperazine
- Objectives of Scale-up
- Pilot Plant with 16.8-inch Contactors
- Comparison of Bench and Pilot Results
- Conclusions

K_2CO_3 Promoted by Piperazine (PZ)

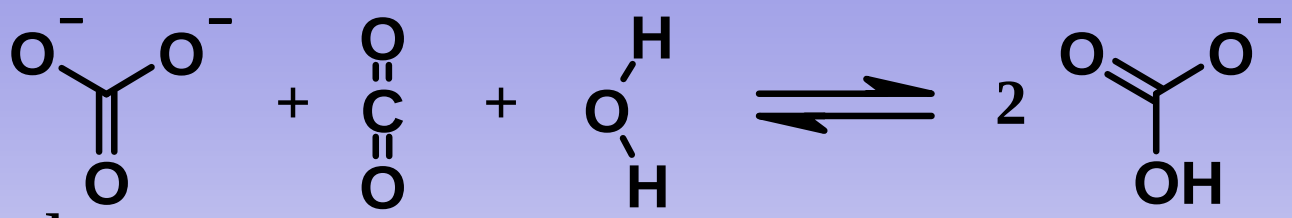
- New Solvent Developed by Cullinane (2005)
  - 2.5 m PZ / 2.5 m K_2CO_3
  - CO_2 Absorption 1.5 – 3 Times Faster than 30 wt% MEA
  - Heat of Absorption 10-25% Less than MEA
- Implications
  - 1.5-2.5 less Packing and Pressure Drop

    OR
  - Closer Approach to Saturation - 10-20% Less Energy

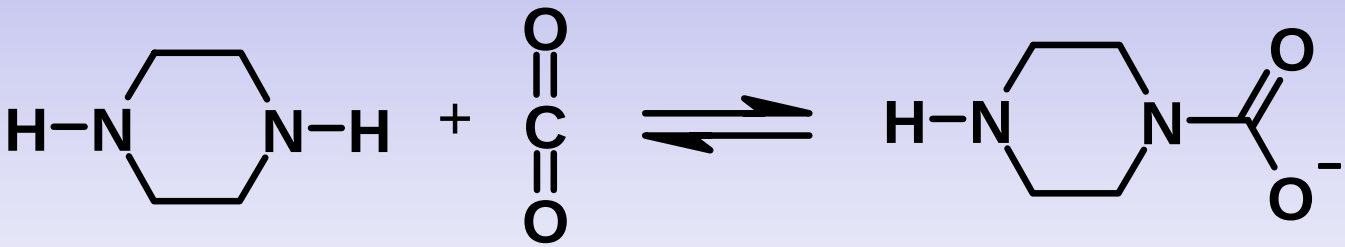
Wetted Wall Column



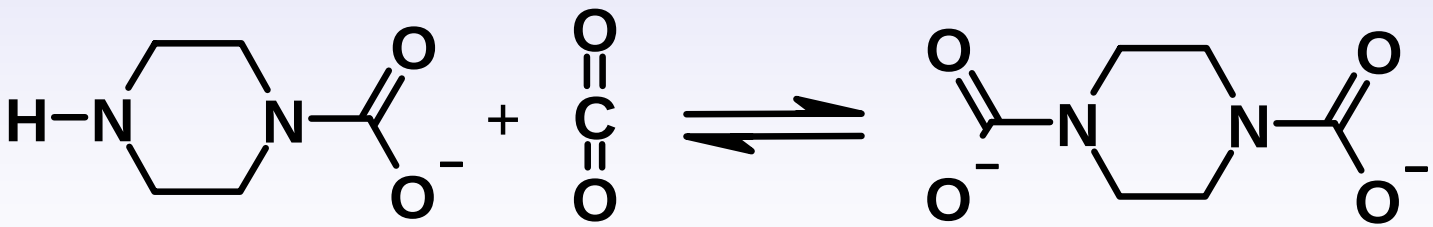
CO_2 Absorption by K^+/Piperazine



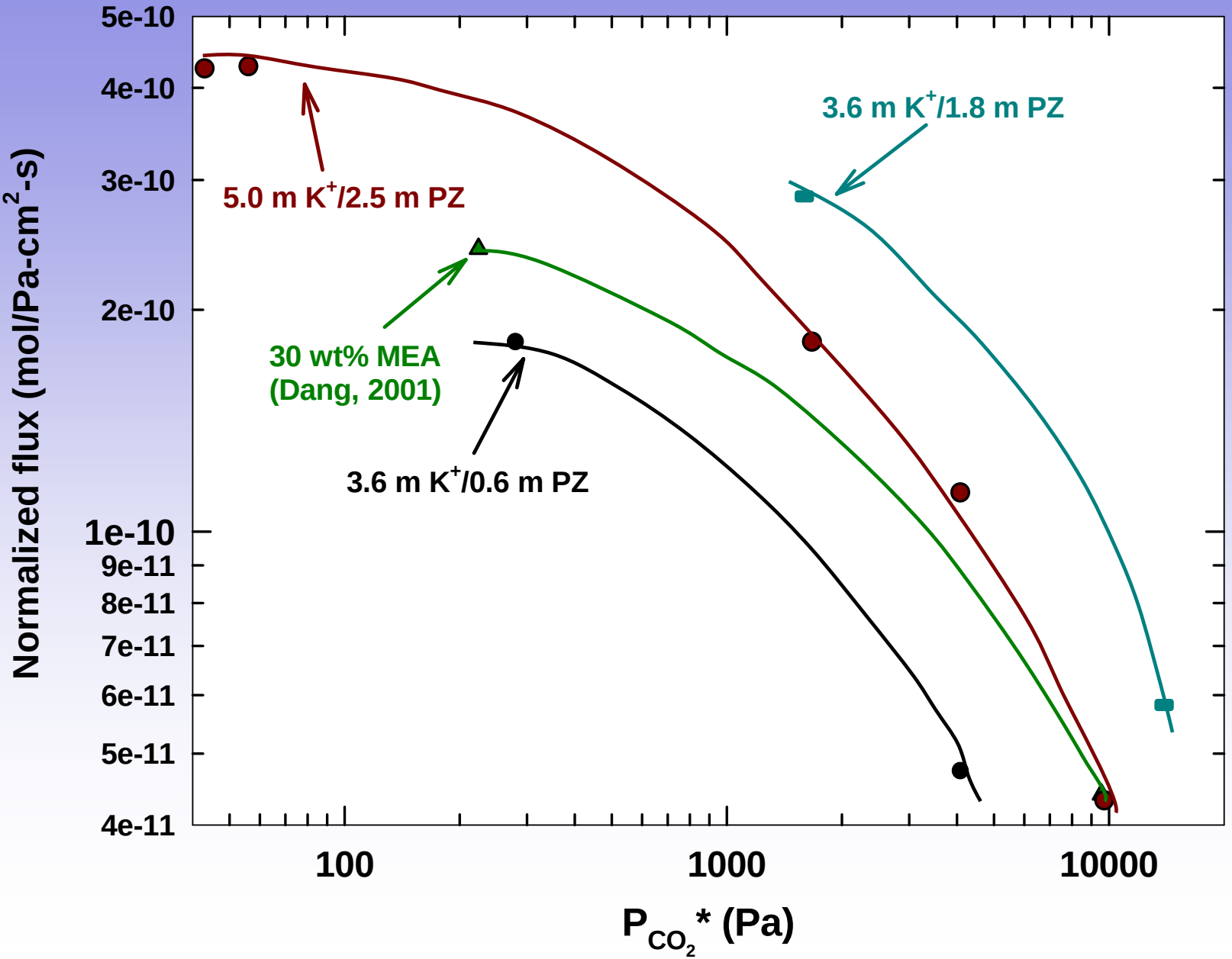
Carbonate



PZ



Wetted Wall Data at 60°C



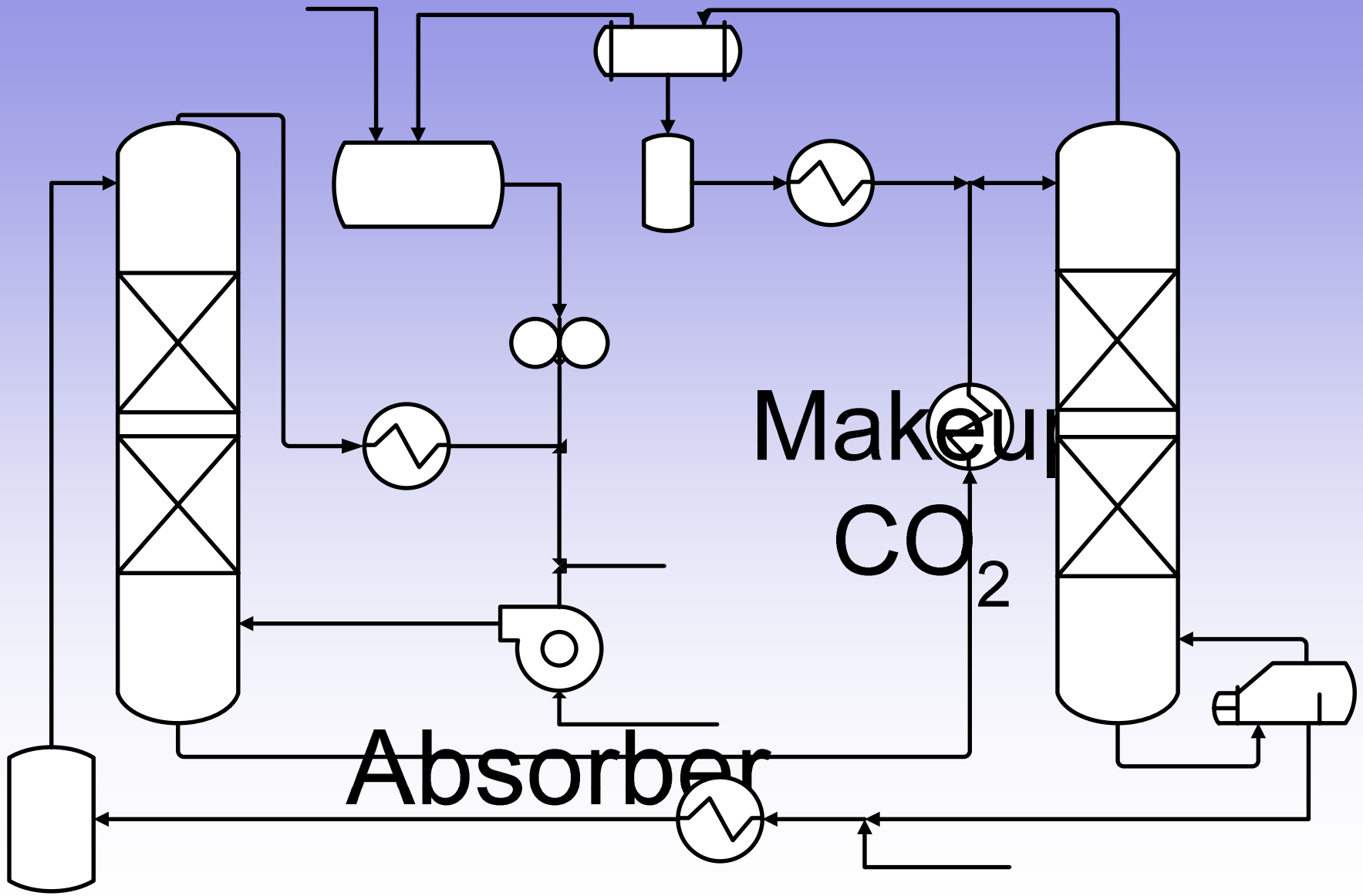
Research Objectives

- Develop & Validate Design Methods for Scaleup from Bench-scale Measurements
  - CO_2 Absorption in Potassium Carbonate Promoted by Piperazine
  - Wetted Wall Column & Absorber Pilot Data
- Characterize & Understand T Bulges
- Demonstrate Reliable Operation of System
- Target Application – Coal-Fired Power Plants

CO_2 Pilot Absorber/Stripper System

- Pickle Research Center
- Column ID – 16.8 in
- Packed Height – 20 ft in 2 Beds (10 ft Each)
- Collector Plate & Redistributor in Between Packed Beds
- Multi-use facility (distillation/extraction)

Pilot Plant Schematic



Campaign 2 Summary

Absorber Packing	Flexipac 1Y
Stripper Packing	IMTP #40
K_2CO_3 Conc. (wt%)	22
K^+/PZ	2
Inlet CO_2 (%)	2.6 – 12.6
CO_2 Removal (%)	60 – 97.5
Lean Ldg (mol CO_2/K+2PZ)	0.4 – 0.49
$P_{STRIPPER}$ (atm)	0.3 – 1.8

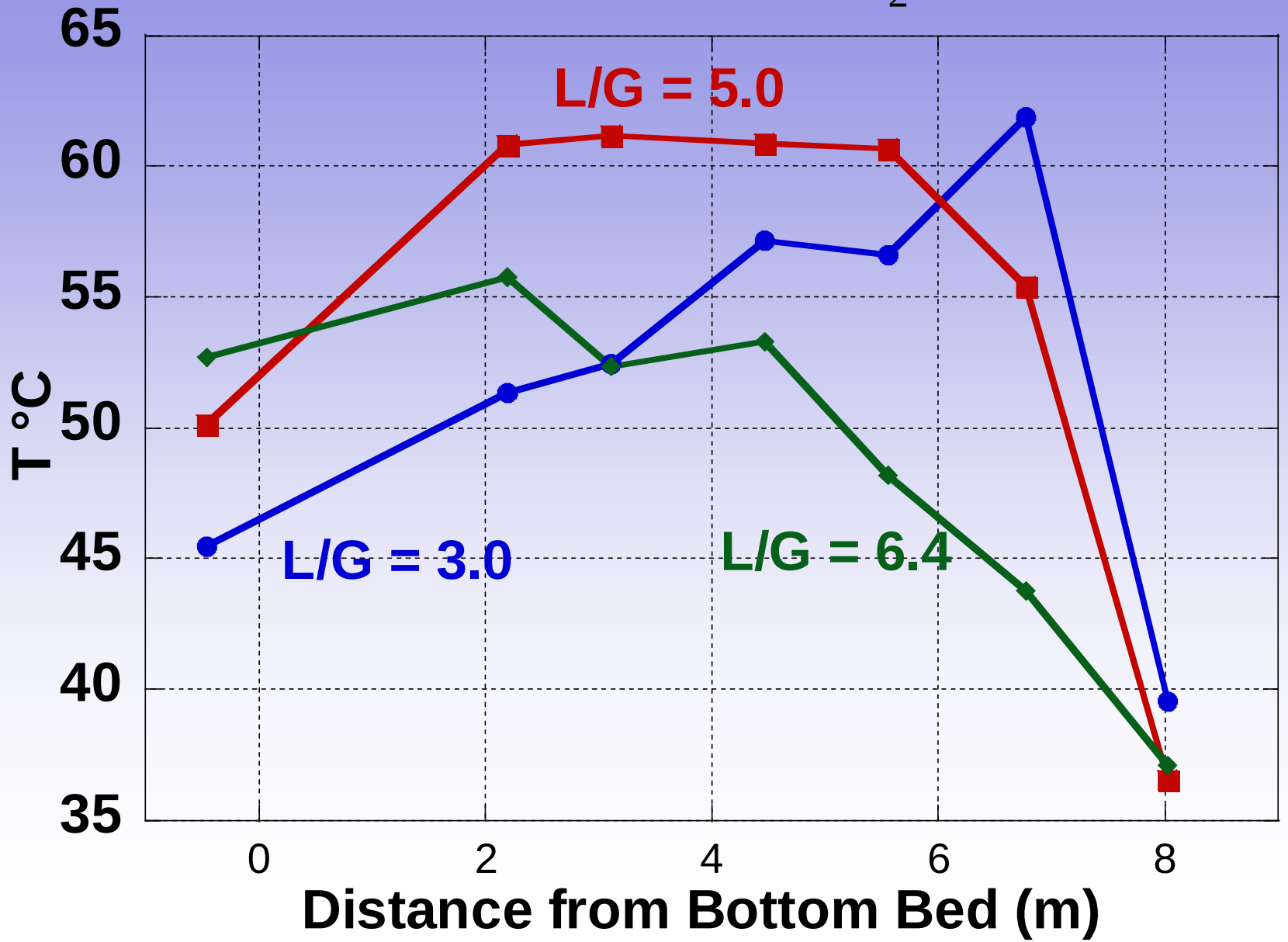
Absorber Rate Data Analysis

$$K_G = \left(\frac{G}{a_{eff}}\right) \frac{\ln\left[\dfrac{CO_{2,IN} - CO^*_{2,IN}}{CO_{2,OUT} - CO^*_{2,OUT}}\right]}{\dfrac{\left(\left(CO_{2,IN} - CO^*_{2,IN}\right) - \left(CO_{2,OUT} - CO^*_{2,OUT}\right)\right)}{\left(CO_{2,IN} - CO_{2,OUT}\right)}}$$

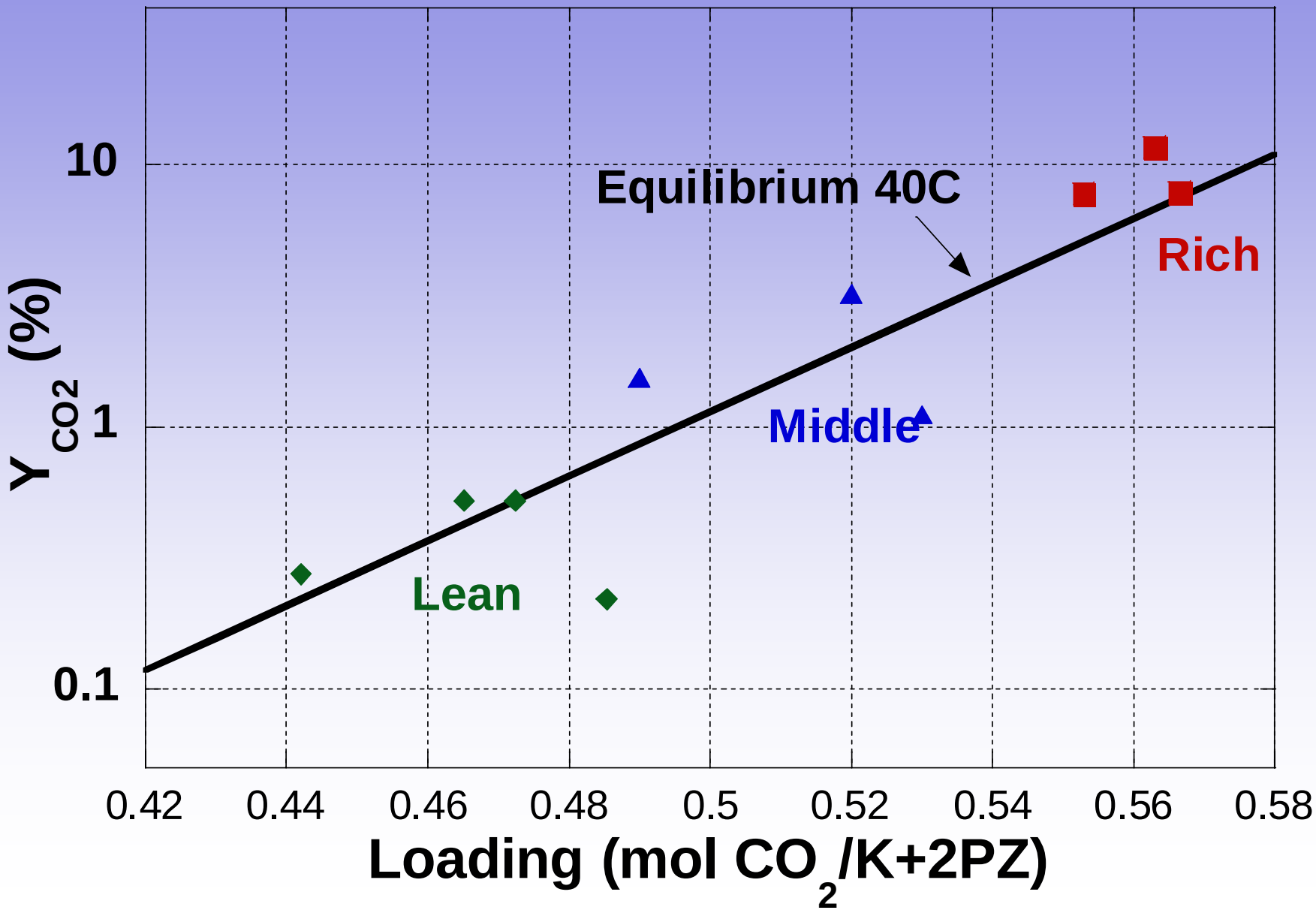
- G = Inlet Gas Rate
- a_{eff} = Correlated Effective Area from KOH Data
- Calculate P_{CO2}^* from Model Fitted to Bench-scale VLE Data
- Calculated K_G for Top, Bottom and Overall Bed
- Validated Bench-scale VLE with Pinch Points in Absorber
- Plot K_G against Average Loading Across Bed(s)

Absorber Temperature Profiles

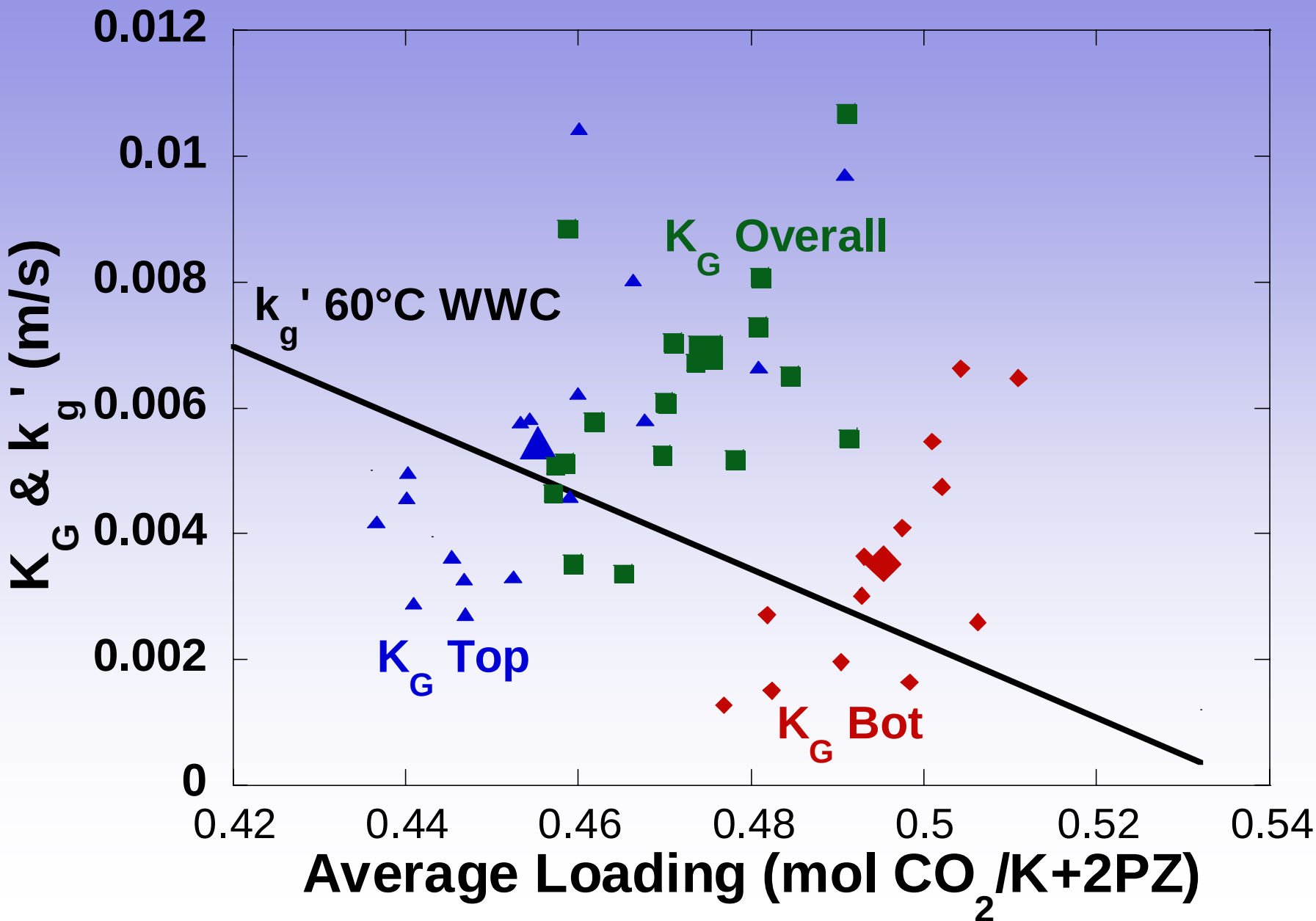
8 – 12.4% Inlet CO_2



VLE Pinch Analysis



Mass Transfer Results



Stripper Operation at 1.6 atm

Reboiler T – Rich Solvent T (°C)	38 – 52
Top T (°C)	83 – 113
Bottom T (°C)	117 – 122
Reboiler Heat Duty (kcal/mol CO_2)	107 – 177

- Inadequate Preheat of Stripper Feed
- New Cross-Exchanger in Next Campaign

Conclusions

- Matched VLE from Bench-scale Data
- CO_2 Absorption Rates are 1.5 – 3 Times Higher than Bench-scale
- Average Top and Bottom K_G Approximately Matched Bench-scale Data
- Temperature Bulge Varied from 18 to 33 °C with High CO_2

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Questions?